

PROCESS FOR THE PREPARATION OF NITRODIPHENYLAMINES

FIELD OF THE INVENTION

The present invention relates to a process for the preparation of nitrodiphenylamines by reaction of nitrohalogens with anilines, a base and a catalyst, and to a process for the preparation of aminodiphenylamine by hydrogenation of the
5 nitrodiphenylamine intermediately prepared.

BACKGROUND OF THE INVENTION

N-Substituted anilines are important intermediate products for the preparation of agricultural and fine chemicals.

10

As described in Kirk-Othmer, Encyclopedia of Chemical Technology, 4th edition, 1992, vol. 3, page 424-456 and in Ullmann's Encyclopedia of Industrial Chemistry, 5th edition, vol. A3, 1985, page 91-111, 4-aminodiphenylamine (4-ADPA) is an important precursor for the synthesis of anti-ageing agents and
15 stabilizers in the rubber and polymers industry.

Hartwig describes in Angew. Chem., Int. Ed. 1998, 37, 2046-2067 and Buchwald in Top. Curr. Chem. 2002, 219, 131-209, that the synthesis of N-substituted anilines can also be carried out by coupling, catalyzed by transition metals, of
20 activated chloro-, bromo- or iodoaromatics with primary or secondary amines, optionally in the presence of a palladium catalyst, a phosphane and a base.

WO-A2 01/66248 discloses that instead of the complex Pd-phosphane complexes, N-heterocyclic Pd-carbene complexes can also alternatively be employed.

25

The disadvantage of the syntheses described in the prior art cited above is the use of palladium, which is poorly available and subject to wide price variations, and is expensive to recover. The use of the phosphane ligands of the specifications cited

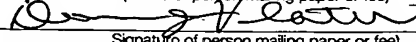
"Express Mail" mailing label number EV 236381435

Date of Deposit January 2, 2004

I hereby certify that this paper or fee is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 CFR 1.10 on the date indicated above and is addressed to the Commissioner of Patents and Trademarks, Alexandria, VA 22313-1450.

Donna J. Veatch

(Name of person mailing paper or fee)


Signature of person mailing paper or fee

in the prior art also presents problems because of their poor availability and their high toxicity.

DE-A 3 246 151, DE-A 3 501 698, DE-A 185 663, U.S. Patent Nos. 4,670,595,
5 4,187,249, 4,683,332 and 4,187,248 disclose the preparation of N-substituted
anilines from p-nitrochlorobenzene in the presence of an acid acceptor or a
neutralizing agent with the aid of copper catalysts.

U.S. Patent No. 5,840,982 reports that the first stage for the preparation of
10 N-substituted anilines is usually carried out with copper catalysts, and the second
with metal components which differ from these, e.g. nickel.

Venkatamaran et al. discloses in Tetrahedron Letters, 2001, 42, 4791-4793 that
the preparation of triaryl amines from diaryl amines and iodoaromatics is possible
15 in high yields with the aid of defined copper-phosphane complexes. Selective
preparation of diaryl amines, which are very important economically, is not
described in this publication.

Buchwald et al. describes in Organic Letters, 2002, 4, 581-584 the general
20 reaction of halogenobenzenes with anilines. The use of the catalyst according to
formula (I) is not disclosed.

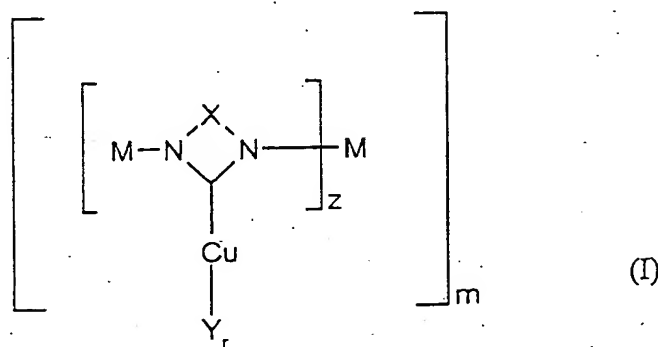
There was therefore the need to develop catalysts, which are suitable in an
advantageous manner for a process for the preparation of nitrodiphenyl amines
25 starting from aryl chlorides and aryl bromides.

Since aryl chlorides are usually significantly slower to react in nucleophilic
aromatic substitution than aryl iodides, significantly more drastic conditions, such
as high temperatures, must be chosen for such a reaction. This is in general
30 accompanied by a significantly reduced selectivity of the reaction.

The object of the present invention is therefore to provide a process, which renders it possible to react nitrohalogenobenzenes with anilines to give nitrodiphenylamines in high yields and with a high selectivity.

SUMMARY OF THE INVENTION

The present invention is directed to a process for the preparation of nitrodiphenylamines, wherein nitrohalogenobenzenes are reacted with anilines, a base and a catalyst of the formula (I)



wherein

X is a 1,2-ethanediyl or 1,2-ethenediyl radical and

M can be identical or different and represents C₁-C₁₉-alkyl, C₇-C₁₉-aralkyl, C₆-C₁₈ aryl groups or C₆-C₁₉-heteroaryls having 1 to 3 nitrogen atoms, wherein two or more radicals M can be bridged in any desired manner by a covalent bridge or by an alkylidene bridge containing 1 to 4 carbon atoms or via an aryl or heteroaryl ring,

Y represents halogen or a trifluoroacetyl, trifluoromethanesulfonyl, nonafluorobutanesulfonyl, cyanide, acetyl, fluorinated acetylacetonyl, nitrate, arylsulfonyl, oxinate, phosphate, carbonate or tetrafluoroborate radical,

z represents 1, 2 or 3,

m represents integers from 1 to 6 and

5 r denotes 0, 1 or 2.

The base for the process according to the present invention can be chosen from the group consisting of bicarbonates, carbonates, methanolates, ethanolates, isopropylates, tert-butanolates, phosphates, fluorides, silazanes, hydrides and
10 acetates of lithium, sodium, potassium and caesium.

The catalyst of the formula (I) can also be prepared in situ for the process according to the present invention.

15 The present invention also provides a process for the preparation of aminodiphenylamine, wherein the nitrodiphenylamine prepared by the process according to the present invention is hydrogenated, without isolation.

In the general formula (I)

20

X preferably represents a 1,2-ethenediyl group,

M preferably represents a C₁-C₁₂ alkyl group, C₅-C₇ cycloalkyl group, C₆-C₁₂-aryl group or a C₅-C₁₂ heteroaryl group having 1 to 3 nitrogen atoms
25 in the ring, or represents a methyl group, which is bridged in any desired manner with another radical M by a covalent bridge or by an alkylidene bridge containing 1 to 4 carbon atoms or via an aryl or heteroaryl ring. C₁-C₁₂ alkyl groups are to be understood as meaning both branched and unbranched alkyl groups. Methyl, ethyl, n-propyl, i-propyl, n-butyl and
30 tert-butyl are preferred. C₅-C₆ Cycloalkyl groups are preferably to be understood as meaning cyclopentyl and cyclohexyl groups. Phenyl, biphenyl or the naphthyl radical are preferably employed as C₆-C₁₂-aryl

groups. Pyridyl or quinolyl radicals are the preferred C₅-C₁₂-heteroaryl radical having 1 to 3 nitrogen atoms.

5 Y preferably represents chlorine, bromine, iodine or a trifluoromethylsulfonyl or an acetyl radical.

z preferably represents 1 or 2

10 m preferably represents 1, 2 or 3

r preferably represents 1 or 2

Copper compounds with a valency level of 0, +I or +II are preferably employed for the preparation of the catalysts. Preferred starting compounds for the catalysts
15 include copper oxides, copper halides, copper cyanides and copper acetates, copper acetylacetonates in fluorinated or non-fluorinated form, copper nitrates, copper trifluoromethanesulfonates, copper arylsulfonates, copper oxinates and copper phosphates, more preferred are copper(I) chloride, copper(I) bromide, copper(I) iodide, copper(II) bromide, copper(II) chloride, copper(II) acetate,
20 copper(II) oxide or copper(II) acetylacetonate, as well as copper powder. Copper(I) chloride, copper(I) bromide or copper(I) trifluoromethanesulfonate are most preferred.

Those catalysts which contain two symmetric, unsymmetric or two bridged
25 ligands are preferred. Symmetric dialkylimidazolidenes, diarylimidazolidenes and diheteroarylimidazolidenes, unsymmetric arylalkylimidazolines and N-substituted imidazolidenes bridged via heteroaryls or alkylidene bridges are particularly preferred. N,N'-Dimethylimidazolidene, N,N'-dicyclohexylimidazolidene, N,N'-diphenylimidazolidene, N,N'-di(2,6-diisopropyl)phenylimidazolidene, N,N'-
30 di(2,6-dimethyl)phenylimidazolidene, N,N'-di(2,4,6-trimethyl)phenylimidazolidene, N,N'-di(2-pyridyl)imidazolidene, N-benzyl-N'-methylimidazolidene and ligands which are formed by two-fold deprotonation of

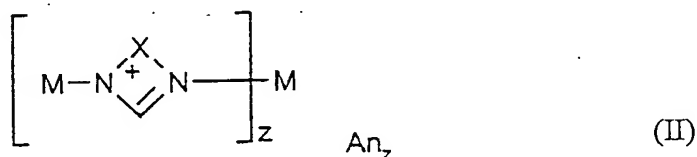
1,3-bis[N-(N'-methyl)imidazoliummethyl]-5-methylbenzene dihalide, 2,6-bis-[N-(N'-methyl)-imidazoliummethyl]pyridine dihalide, 1,2-bis-[N-(N'-methyl)-imidazolium]-1,2-diphenylethane halide or bis-[N-(N'-methyl)imidazolium]-methane dihalide are very particularly preferred.

5

Preferred catalysts of the formula (I) include (N,N'-dimethylimidazolidene)-copper(II) bromide, (N,N'-dicyclohexylimidazolidene)-copper[II] bromide, [N,N'-di(2,4,6-trimethyl)phenylimidazolidene]-copper(II) bromide, [N,N'-di(2-pyridyl)imidazolidene]-copper[II] bromide, (N-benzyl-N'-methylimidazolidene)-copper[II] bromide, {1,3-bis-[N-(N'-methyl)imidazolidene-methyl]-5-methylbenzene}-copper[II] bromide, {1,3-bis-[N-(N'-methyl)imidazolidene-methyl]-5-methylbenzene}-copper[I] trifluoromethylsulfonate, {2,6-bis-[N-(N'-methyl)-imidazolidenemethyl]pyridine}-copper[II] bromide, {1,2-bis-[N-(N'-methyl)imidazolidene]-1,2-diphenylethane}-copper[II] bromide and {bis-[N-(N'-methyl)imidazolidene]methane}-copper[II] bromide. (N,N'-Dimethylimidazolidene)-copper(II) bromide and {1,3-bis-[N-(N'-methyl)imidazolidenemethyl]-5-methylbenzene}-copper[II] bromide are particularly preferred.

The catalysts mentioned can be employed either individually or in any desired mixture with one another. The most favorable mixture composition can be determined by appropriate preliminary experiments.

The catalysts of the formula (I) to be employed according to the present invention are prepared by deprotonation of ligands of the formula (II)



25

with a base and subsequent reaction with a copper compound of the formula (III)



wherein M, X, Y, z and r have the meaning given in the case of the formula (I).

Formula (II) is representative here of the possible tautomeric compounds, which are also included in the scope of the invention.

"An" is preferably an anion of an acid which has a pKa value of 3 or less than 3.

- 5 "An" is more preferably hydrogen sulfate, chloride, bromide, iodide, tetrafluoroborate, hexafluorophosphate or one half of an equivalent of sulfate.

"An" is most preferably chloride, bromide or iodide.

- 10 Bases which are employed for the deprotonation of the ligand include alkali metal and/or alkaline earth metal alcoholates, hydrides and/or hydroxides. Preferred bases for the deprotonation of the ligands are sodium methanolate, potassium tert-butylate, potassium amylate, sodium hydride, potassium hydride, potassium hydroxide, sodium hydroxide and barium hydroxide. The deprotonation of the
15 ligands preferably takes place by potassium tert-butylate.

- The solvents for the deprotonation of the ligand are inert organic solvents. Ethers, such as diethyl ether and THF, and also toluene, xylene, chloroform, methylene chloride, methanol and/or ethanol are preferred, the deprotonation being carried
20 out in the temperature range from -50 to 50°C. Preferably, the deprotonation is carried out in ethers at temperatures of between -35° and room temperature.

- For the preparation of the catalysts of the formula (I), the starting substances of the formula (II) and of the formula (III) are employed in a molar ratio such that
25 the desired target catalyst of the general formula (I) results. The molar ratio of the imidazolium salts of the formula (II) to the copper compounds of the formula (III) is preferably chosen in the range from 40:1 to 0.5:1, more preferably in the range from 5:1 to 1:1, most preferably in the range from 4:1 to 1:1.

- 30 The solvents required for the preparation of the catalysts are the same as those used for the deprotonation of the ligand. The most favorable amount of solvent to be employed can be determined by appropriate preliminary experiments. When

the deprotonation is complete, the reaction temperature is increased to a temperature in the range from 10 to 30°C. The temperature is preferably increased to temperatures in the range from 15 to 25°C in the course of 60 to 180 minutes.

- 5 The catalysts either can be added as an isolated compound to the process according to the present invention for the preparation of diarylamines, or can also be reacted in situ during the reaction of the substituted benzenes with the arylamines.
- 10 For the process according to the present invention, the catalysts are employed in amounts of 0.02 mol% to 10 mol%, preferably 0.1 mol% to 3 mol%, based on the amount of nitrohalogenobenzenes employed.

- Nitrohalogenobenzenes are to be understood as meaning all
- 15 nitrohalogenobenzenes which contain at least one halogen chosen from the group consisting of fluorine, chlorine and bromine. Preferred halogens are fluorine and chlorine. In addition to the halogen and the nitro group, the nitrohalogeno-
=benzenes can also contain one or more substituents chosen from the group consisting of C₁-C₁₂-alkyl groups. The unsubstituted nitrohalogenobenzenes and
- 20 nitroalkylhalogenobenzenes with unbranched alkyl groups are preferred. The nitrohalogenobenzenes and nitroalkylhalogenobenzenes in which the nitro group is in the para-, ortho- or meta-position relative to the halogen, preferably in the para-position, are more preferred. 4-Nitro-2-methylchlorobenzene, 4-nitro-3-methylfluorobenzene, 4-nitrochlorobenzene, 3-nitrochlorobenzene and 2-
- 25 nitrochlorobenzene are most preferred. Of these, 4-nitrochlorobenzene is preferred.

- In addition to aniline, all the o-, m- and p-substituted anilines known to the expert can also be employed in the process according to the present invention. Preferred
- 30 substituents are branched or unbranched C₁-C₂₉-alkyl, C₂-C₂₉-alkenyl, C₁-C₂₉-acyl, C₁-C₂₉-alkylthio, C₁-C₂₉-alkyl-amino and C₁-C₂₉-alkoxy radicals, C₁-C₂₉ carboxylic acid esters having 1 to 29 C atoms in the carboxylic acid part and 1 to

29 C atoms in the ester part and sulfonic acid radicals having 1 to 9 carbon atoms in the ester part. Branched or unbranched alkyl, alkenyl or alkylthio groups with the numbers of carbon atoms mentioned, such as the methyl, n-butyl, tert-butyl, octyl, decyl, dodecyl, myristyl and stearyl group, are preferred. Preferred
5 substituted anilines are vinylaniline, 4-tert-butylaniline, p-anisidine, o-anisidine, o-toluidine, p-toluidine, anthranilic acid methyl ester, o-aminobenzonitrile, p-aminobenzonitrile and 4-ethylaniline. Aniline is most preferred.

In the process according to the invention, in general 1 to 10 mol, preferably 1.5 to
10 8 mol, more preferably 2 to 6 mol of the corresponding aniline are employed per mol of nitrohalogenobenzene.

Bases which are employed in the process according to the present invention are alkali metal and/or alkaline earth metal carbonates, alcoholates, phosphates,
15 fluorides and/or hydroxides, where potassium carbonate, sodium carbonate, caesium carbonate, caesium bicarbonate, sodium methanolate, potassium tert-butylate, potassium amylate, caesium fluoride, potassium phosphate and barium hydroxide are preferred. Potassium carbonate, sodium carbonate, caesium carbonate and/or caesium bicarbonate are more preferred. Potassium carbonate is
20 most preferred.

The bases can be employed either in less than the stoichiometric or the stoichiometric amount or in an excess of up to ten times the equivalent amount with respect to the nitrohalogenobenzene. The bases are preferably employed in
25 0.3 to 2 equivalent amounts, based on the nitrohalogenobenzene.

It is of advantage for the process according to the present invention if the bases employed are pretreated by grinding and/or drying.

30 The grinding can be carried out in commercially available mills in the process according to the present invention. The grinding has the effect here of a drastic increase in the specific surface area, which leads to a significant increase in the

conversion. In many cases an increase in the specific surface area by a factor of 10 to 20 is to be observed by the grinding.

After the grinding the specific surface areas of the bases are approx. 0.1 to 10
5 m^2/g , preferably 0.2 to 1 m^2/g (BET).

Because of the pronounced hygroscopic properties of the bases employed in the process according to the present invention, the phosphates and carbonates above all tend towards a greater or lesser uptake of constituents from the atmosphere,
10 such as water and carbon dioxide. At and above an uptake of approx. 30 per cent by weight of constituents from the atmosphere, a significant influence on the conversions to be achieved is detectable. In addition to grinding, drying of the bases is therefore often also necessary.

15 Drying of the bases is carried out here, depending on the nature of the base used, such that they are heated to temperatures of approx. 50 to 200°C, preferably 100 to 160°C, under a reduced pressure of approx. 0.01 to 100 mbar for several hours.

The process according to the present invention is preferably carried out by a
20 procedure in which the base is first dried at temperatures in the range from 20 to 250°C, preferably at temperatures from 110 to 210°C, the temperature in the reaction vessel is cooled and the nitrohalogenobenzenes, anilines and the catalyst or, in the case where the catalyst is prepared in situ, the ligand according to formula II with the copper compound according to formula III are then added.

25 The process according to the present invention can be carried out either in the presence or in the absence of an additional suitable solvent. Inert organic hydrocarbons, such as xylene and toluene, are preferred as the additional solvent. The aromatic amines employed can themselves furthermore function as the
30 solvent.

The amount of solvents to be employed can easily be determined by appropriate preliminary experiments.

5 In order to increase the yield of nitrodiphenylamines, the water of reaction formed can be removed by distillation, as described in DE-A 2 633 811 and DE-A 3 246 151, by addition of a suitable entraining agent, such as benzene, toluene or xylene.

The process according to the present invention can be carried out in a continuous or discontinuous manner by the methods known to the expert.

10

The nitrodiphenylamines prepared by the process according to the present invention can be reduced to the corresponding aminodiphenylamines by a hydrogenation. The hydrogenation is carried out in the manner known to the expert with a reducing agent, such as hydrogen, during which the copper from the
15 formula (I) already present does not have to be removed and optionally a suitably inert catalyst support.

It is of course also possible to carry out the hydrogenation in the presence of additional hydrogenation catalysts, such as those based on nickel, palladium or
20 platinum. Suitable catalyst supports can also be used for these catalysts.

Suitable materials for use as the catalyst support include all the catalyst supports known to the expert based on carbon, element oxides, element carbides or element salts in various use forms. Examples of carbon-containing supports are coke,
25 graphite, carbon black or active charcoals. Examples of the element oxide catalyst supports are SiO_2 - in the form of naturally occurring or synthetic silica and naturally occurring or synthetic quartz - Al_2O_3 , preferably α - and γ - Al_2O_3 , aluminas, preferably naturally occurring or synthetic aluminosilicates, such as zeolites, laminar silicates, such as bentonite, montmorillonite, TiO_2 , preferably in
30 the rutile or anatas type, ZrO_2 , MgO and ZnO . Examples of element carbides and salts are SiC , AlPO_4 , BaSO_4 and CaCO_3 . In principle, both synthetic materials and supports of natural sources, such as pumice, kaolin, bleaching earths,

bauxites, bentonites, kieselguhr, asbestos or zeolites, can be used. Active charcoals and Si-, Al-, Mg-, Zr- and Ti-containing materials are preferably employed as the support materials. Active charcoal is more preferred.

- 5 The hydrogenation can of course also be carried out with other reduction methods, such as are known to the expert and are described in Reductions in Organic Chemistry, Second Edition, ACS Monograph 188.

10 For the hydrogenation, the nitrodiphenylamine can either be isolated, or the nitrodiphenylamine obtained from the process according to the present invention is hydrogenated directly, alkyl halides being removed, but without further working up.

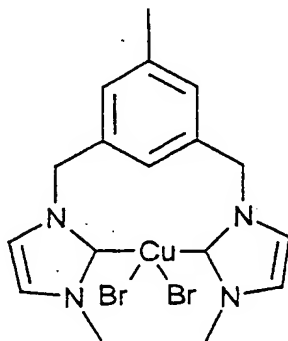
The temperatures during the hydrogenation are approximately 0 to 200°C, preferably 40 to 150°C. The hydrogen pressures for the hydrogenation are 0.1 to 150 bar, preferably 0.5 to 70 bar, more preferably 1 to 50 bar.

The corresponding aminodiphenylamines are obtained by the process according to the present invention with a high selectivity (>95%) and yields of up to 97% of theory.

20

EXAMPLESExample 1

Preparation of {1,3-bis-[N-(N'-methyl)imidazolidene-methyl]-5-methylbenzene}-
5 copper[II] bromide, $C_{17}H_{20}Br_2CuN_4$ (x 2KBr)

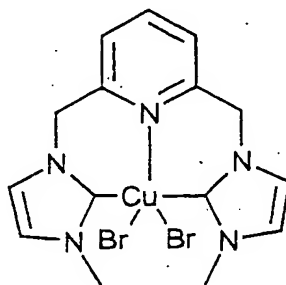


The bisimidazolium salt (135 mg, 0.31 mmol) is dissolved in 10 ml toluene under an argon atmosphere, and potassium tert-butyrate (71 mg, 0.63 mmol) is added at 0°C. After 2 h copper(II) bromide (70 mg, 0.31 mmol) is added and the mixture is stirred for a further 12 h. The solvent is then removed in vacuo, and the product is obtained as a pale powder.

FD/MS: 343 (M-2Br, main component), 423 (M-Br), 503 (M+2H)

Example 2

Preparation of {1,3-bis-[N-(N'-methyl)imidazolidene-methyl]-benzene}-
5 copper[II] bromide, $C_{15}H_{17}Br_2CuN_5(x \text{ } 2KBr)$

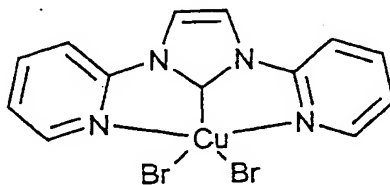


The bisimidazolium salt (131 mg, 0.31 mmol) is dissolved in 10 ml toluene under
an argon atmosphere, and potassium tert-butyrate (71 mg, 0.63 mmol) is added at
10 0°C. After 2 h copper(II) bromide (70 mg, 0.31 mmol) is added and the mixture is
stirred for a further 12 h. The solvent is then removed in vacuo, and the product is
obtained as a pale powder.

FD/MS: 330 (M-2Br, main component), 410 (M-Br), 490 (M+2H)

Example 3

Preparation of [N,N'-di(2-pyridyl)imidazolidene}-copper[II] bromide,
15 $C_{13}H_{10}Br_2CuN_4(x \text{ } KBr)$



20

The imidazolium salt (92 mg, 0.31 mmol) is dissolved in 10 ml toluene under an
argon atmosphere, and potassium tert-butyrate (36 mg, 0.31 mmol) is added at

0°C. After 2 h copper(II) bromide (70 mg, 0.31 mmol) is added and the mixture is stirred for a further 12 h. The solvent is then removed in vacuo, and the product is obtained as a pale powder.

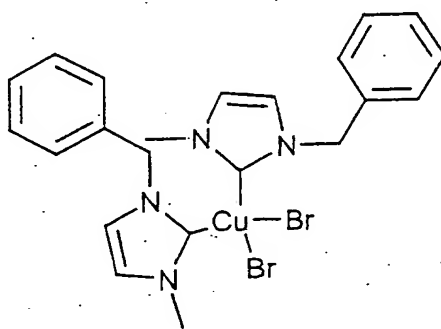
FD/MS: 364 (M-Br, main component).

5

Example 4

Preparation of (N-benzyl-N'-methylimidazolidene)-copper[II] bromide,

$C_{22}H_{24}Br_2CuN_4$ (x 2KBr)



10

The imidazolium salt (300 mg, 1.2 mmol) is dissolved in 10 ml toluene under an argon atmosphere, and potassium tert-butyrate (138 mg, 1.2 mmol) is added at 0°C. After 2 h copper(II) bromide (120 mg, 0.6 mmol) is added and the mixture is stirred for a further 12 h. The solvent is then removed in vacuo, and the product is

15 obtained as a pale powder.

FD/MS: 316 (M-2Br, main component).

Example 5

20 Preparation of 4-nitrodiphenylamine catalyzed by Cu-carbene {1,3-[bis-(N-(N'-methyl)imidazolidene methyl]-5-methylbenzene)-copper(II)-bromide

288.9 g (3,090 mmol) aniline, 83.6 g (605 mmol) potash (preparation: ground for 60 sec at level 1 and 3 x 60 sec at level 2 of a laboratory mixer, the ground

25 material being loosened by shaking after each 60 sec) and 157.6 g (1,000 mmol)

4-chloronitrobenzene and 9.42 g (16.2 mmol) {1,3-bis-[N-(N'-methyl)imidazolidene-methyl]-5-methylbenzene}-copper[II] bromide were initially introduced, while stirring, into a multi-necked round-bottomed flask with a KPG stirrer with a Teflon blade, Vigreux column, 55 ml water separator filled with xylene, blanketing with nitrogen, septum, heating mushroom and insulation. A red-brown suspension was formed and was heated up to the reflux temperature (stirrer approx. 400 rpm, very gentle stream of N₂). Thereafter, only a slight evolution of water initially occurred, but this increased in the course of the reaction and then remained constant at a low level (tot. approx. 6.9 ml). Sampling (unfiltered) took place every 30 minutes and the samples were analysed by means of HPLC (6-point calibration). After 390 minutes the experiment was ended. The boiling temperature of the mixture was about 192-199°C during the entire duration of the experiment. A residual p-NCB value of 6.0 wt.% (corresponds to 84% conversion), a 4-NDPA content of 32.3 wt.%, a 4,4'-dinitrotriphenylamine content of 1.2% and a 4-NDPA/triarylamine ratio of 27 (corresponds to a yield of 81% 4-NDPA and 96% selectivity, based on the p-NCB) resulted here.

Result

Sample	Sample [min]	p-NCB [wt.%]	4-NDPA [wt.%]	Triple nucleus [wt.%]	Selectivity (NDPA/triple nucleus)
1	30	23.5	8.7	0.00	
2	62	21.0	13.2	0.19	71.0
3	90	18.7	15.3	0.14	112.8
4	121	17.0	18.4	0.36	50.7
5	150	15.8	21.0	0.43	48.5
6	180	15.1	24.6	0.55	44.5
7	210	12.4	25.1	0.37	67.4
8	240	9.8	23.7	0.66	36.0
9	270	8.5	25.5	0.76	33.6
10	302	8.2	30.0	1.00	30.1
11	347	6.6	32.3	1.09	29.6
12	362	6.0	32.3	1.20	26.9

Example 6

Preparation of 4-nitrodiphenylamine catalysed by Cu-carbene {1,3-[bis-(N-(N'-methyl)imidazolidene methyl]-5-methylbenzene)-copper(II)-bromide in the
5 presence of caesium.

288.9 g (3,090 mmol) aniline, 83.6 g (605 mmol) potash (preparation: ground for
60 sec at level 1 and 3 x 60 sec at level 2 of a laboratory mixer, the ground
material being loosened by shaking after each 60 sec) and 157.6 g (1,000 mmol) 4-
10 chloronitrobenzene and 0.50 g (3.78 mmol) Cs as an aqueous solution were
initially introduced, while stirring, into a multi-necked round-bottomed flask with
a KPG-stirrer with a Teflon blade, Vigreux column, 55 ml water separator filled
with xylene, blanketing with nitrogen, septum, heating mushroom and insulation.
A red-brown suspension was formed and was heated up to the reflux temperature
15 (stirrer approx. 400 rpm, very gentle stream of N₂). When the water had been
removed from the circulation the mixture was cooled down to approx. 80°C and
4.71 g (8.1 mmol) {1,3-bis-[N-(N'-methyl)imidazolidene-methyl]-5-methyl-
benzene}-copper[II] bromide were added. After the mixture had been heated up
again to the reflux temperature, only a slight evolution of water initially occurred,
20 but this increased in the course of the reaction and then remained constant at a low
level (tot. approx. 7.2 ml). Sampling (unfiltered) was carried out every 30 minutes
and the samples were analysed by means of HPLC (6-point calibration). After 360
minutes the experiment was ended. The boiling temperature of the mixture was
about 190-198°C during the entire duration of the experiment. A residual p-NCB
25 value of 6.2 wt.% (corresponds to 84% conversion), a 4-NDPA content of 33.9
wt.%, a 4,4'-dinitrotriphenylamine content of 1.92% and a 4-NDPA/triarylamine
ratio of 17.7 (corresponds to a yield of 79% 4-NDPA and 95% selectivity, based
on the p-NCB) resulted here.

Results:

Sample	Sample [min]	p-NCB [wt. %]	4-NDPA [wt. %]	Triple nucleus [wt. %]	Selectivity (NDPA/triple nucleus)
1	30	24.2	8.6	0.13	67.7
2	60	19.1	12.8	0.14	92.9
3	90	18.5	17.0	0.34	50.4
4	135	16.4	20.7	0.53	39.0
5	150	15.4	21.9	0.63	34.7
6	180	13.6	24.7	0.78	31.8
7	210	12.5	24.8	0.95	26.2
8	270	9.2	29.0	1.33	21.9
9	300	8.3	31.7	1.56	20.3
10	343	7.2	33.9	1.80	18.8
11	362	6.2	33.9	1.92	17.7

Example 7

5

Preparation of 4-aminodiphenylamine

250 ml water were added to the reaction mixture from example 5, after cooling to 105°C, and the mixture was stirred for 15 min at 80°C and transferred to a separating funnel. After phase separation had taken place, 8 ml KOH, 25 ml salt water (from the aqueous phase of the condensation) and 4.5 g Raney nickel were added to the organic phase (500 ml) which had been separated off, the mixture was transferred to a hydrogenating autoclave and hydrogenation was carried out under a pressure of 10 bar of hydrogen in the course of 400 min, a temperature of 140°C being reached. According to analysis by gas chromatography, 91% 4-aminodiphenylamine (based on the 4-nitrodiphenylamine employed) is obtained.

10

15